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Electromagnetic

Lecture (12)

Chapter (8)

"Magnetic Forces"

2nd year
communications

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Lecture (12)

Chapter (8)

Magnetic forces

[1] Force on a moving charge Q :

⇛ The electric force on Q :

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$$\bar{F}_e = Q\,\bar{E}$$

القوة الكهربية تكون في نفس إتجاه المجال الكهربي .

⇛ The magnetic force on Q that is moving with $\bar{u}$ velocity :

$$\bar{F}_m = Q\,\bar{u} \times \bar{B}$$

القوة المغناطيسية تكون عمودية على إتجاه المجال المغناطي

وأيضاً في نفس الوقت تكون عمودية على إتجاه حركة الشحن

«إتجاه السرعة»

$\bar{F}_m \perp \bar{u}$ and $\bar{B}$

$\bar{F}_e \parallel \bar{E}$

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⇛ Lorentz force eq$^{\underline{n}}$:

إذا تحركت شحنة Q تحت تأثير مجالين (كهربي ومغناطيسي)

فإن القوة المحصلة تكون :

$$\bar{F} = \bar{F}_e + \bar{F}_m$$

$$= Q[\bar{E} + \bar{u} \times \bar{B}]$$

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$\boxed{3}$ $Q = 18\ nc$

$\bar{u} = 5*10^6\,(0.04\hat{x} - 0.05\hat{y} + 0.2\hat{z})\ m/s$

find $|F| = ??$

Solution

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ⓐ $\bar{B} = -3\hat{x} + 4\hat{y} + 6\hat{z}\ mT.$

$$\bar{F} = \bar{F}_m = Q\,\bar{u} \times \bar{B}$$

$$\therefore F_m = 18*10^{-9}*5*10^{6}*10^{-3}\begin{vmatrix} \hat{x} & \hat{y} & \hat{z} \\ 0.04 & -0.05 & 0.2 \\ -3 & 4 & 6 \end{vmatrix}$$

∴ $\bar{F}_m = 9*10^{-5}[-1.1\hat{x} - 0.84\hat{y} + 0.01\hat{z}]$

∴ $|\bar{F}_m| = 1.38 * 9*10^{-5}$

$= \boxed{124.6\ \mu N}$

(b) $\bar{E} = -3\hat{x} + 4\hat{y} + 6\hat{z}$ kV/m

$\bar{F}_e = Q\bar{E}$

$= 18*10^{-9}*10^{3}[-3\hat{x} + 4\hat{y} + 6\hat{z}]$

$= 18*10^{-6}[-3\hat{x} + 4\hat{y} + 6\hat{z}]$

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∴ $|\bar{F}_e| = \boxed{140.6\ \mu N}$

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(c) $\bar{F}_T = \bar{F}_e + \bar{F}_m$

$= 9*10^{-5}[-1.1\hat{x} - 0.84\hat{y} + 0.01\hat{z}]$

$+ 9*10^{-5}[0.2(-3\hat{x} + 4\hat{y} + 6\hat{z})]$

$= 9*10^{-5}\{-1.7\hat{x} - 0.04\hat{y} + 1.21\hat{z}]$

∴ $|F_T| = \boxed{187.83\ \mu N}$

$\boxed{2}$ The force on a line Carrying Current I :

$$d\bar F = \bar I \, dl \times \bar B \Rightarrow \boxed{\bar F = \int_l \bar I \, dl \times \bar B}$$

$$\boxed{\bar F = \bar I \, l \times \bar B}$$

حفظ

(Const.)

$\bar I$: هو مقدار التيار الذى يمر فى الخط .

l : طول الخط .

$\bar B$: المجال المغناطيسى المؤثر على الخط .

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$\boxed{4}$ $l = 0.3 \text{ m}$ $\quad \bar I = -5\hat z \text{ (A)}$

$\bar B = 3.5 * 10^{-3} [\hat x - \hat y] \text{ T}.$

Solution

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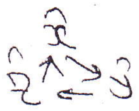
$$\bar F = \bar I \, l \times \bar B$$

$$= -5\hat z \, (0.3) \times (3.5 * 10^{-3}) [\hat x - \hat y]$$

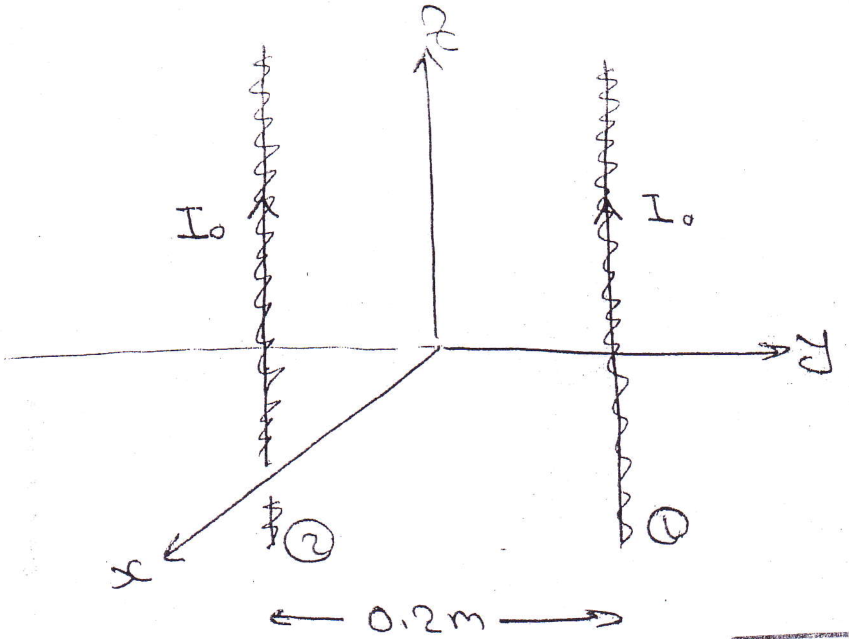
$$= -5.25 * 10^{-3} \, \hat z \times (\hat x - \hat y)$$



$$= -5.25 * 10^{-3} \, (\hat y + \hat x)$$

$$\boxed{\bar{F} = -5.25(\hat{x}+\hat{y})\ mN}$$

$\boxed{5}$



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$I_0 = 10\,A$

find $\bar{F}/l = ??$

Solution

For infinite line current on z-axis: $\bar{H} = \dfrac{I_0}{2\pi\rho}\hat{\phi}$

$$\bar{B} = \mu \bar{H} = \frac{\mu I_0}{2\pi\rho}\hat{\phi}$$

for this Case, we Can use:

$\rho \Leftarrow$ البعد بين الخط والنقطة (0.2m)

$\hat{\phi} \Leftarrow \hat{x}$ or $-\hat{x}$ وذلك يعتمد على

الخط الذي يمر به التيار .

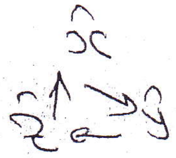
⇛ force on line ①:

$$\bar{H} = \frac{I_o}{2\pi(0.2)}(-\hat{x})$$

تأثير الخط الثاني على الأول

$$\therefore \bar{B} = \mu\bar{H} = \frac{-\mu I_o}{0.4\pi}\hat{x}$$

$$\therefore \bar{F}_1 = \bar{I}_1 l \times \bar{B}$$



$$\therefore \bar{F}_1/l = 10\hat{z} \times \frac{-\mu I_o}{0.4\pi}\hat{x}$$

$$= \underline{-10^{-4}\hat{y}} \text{ N/m}$$

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⇛ force on line ②:

$$\therefore \bar{F}_2/l = 10^{-4}\hat{y} \text{ N/m}$$

∴ It is attractive force (قوة تجاذب بين الخطين)

(كل منهم يسحب الآخر في اتجاهه)

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3 Magnetic B.Cs :

$\Rightarrow B_{n1} = B_{n2}$ (Normal)

$\Rightarrow H_{t1} = H_{t2}$ (Tangent)

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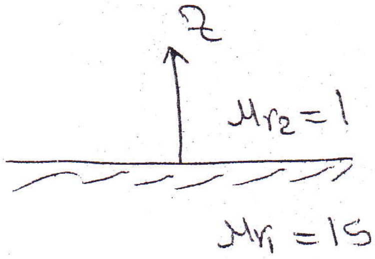
5 $\bar{B}_1 = 1.2\hat{x} + 0.8\hat{y} + 0.4\hat{z}$ (T)

Find $\bar{H}_2$.

Solution



$$\bar{H}_1 = \frac{\bar{B}_1}{\mu_1} = \frac{1.2}{15\mu_0}\hat{x} + \frac{0.8}{15\mu_0}\hat{y} + \frac{0.4}{15\mu_0}\hat{z}$$

$\Rightarrow$ Tangent : $\hat{x}, \hat{y}$

$\therefore H_{t1} = H_{t2}$

$$H_{2x} = H_{1x} = \frac{1.2}{15\mu_0}$$

$$H_{2y} = H_{1y} = \frac{0.8}{15\mu_0}$$

$\Rightarrow$ Normal : $\hat{z}$

$B_{n1} = B_{n2}$

$$\boxed{B_{2z} = B_{1z} = 0.4}$$

$$H_{2z} = \frac{B_{2z}}{\mu_2} = \frac{0.4}{\mu_0}$$

$$\therefore \boxed{\bar{H}_2 = \frac{1.2}{15\mu_0}\hat{x} + \frac{0.8}{15\mu_0}\hat{y} + \frac{0.4}{\mu_0}\hat{z}}$$

Mansoura University
Faculty of Engineering
Communication Engineering Department

Second Year Communication
Electromagnetic Fields
Sheet (9)

[1] In cylinderical coordinates, $\mathbf{B} = (2/p)\ \mathbf{a}_\varphi$ (T). Determine the magnetic flux Φ crossing the plane surface defined by $0.5 \le \rho \le 2.5$ m and $0 \le z \le 2$ m.

[2] Write Maxwell equations – for static electric fields and steady magnetic fields – in the integral form, then derive the point form of these equations.

[3] The point charge $Q = 18$ nC has a velocity of 5×10^6 m/s in the direction $0.04\ \mathbf{a}_x - 0.05\ \mathbf{a}_y + 0.2\ \mathbf{a}_z$. Calculate the magnitude of the force exerted on the charge by the field:

(a) $\mathbf{B} = -3\ \mathbf{a}_x + 4\ \mathbf{a}_y + 6\ \mathbf{a}_z$ mT.

(b) $\mathbf{E} = -3\ \mathbf{a}_x + 4\ \mathbf{a}_y + 6\ \mathbf{a}_z$ KV/m.

(c) **B** and **E** acting together.

[4] Find the force on a straight conductor of length 30 cm carrying a current of 5 A in the $-\mathbf{a}_z$ direction, where the field is $\mathbf{B} = 3.5 \times 10^{-3}\ (\mathbf{a}_x - \mathbf{a}_y)$ T.

[5] Find the forces per unit length on two long, straight, parallel conductors if each carries a current of 10 A in the same direction and the separation distance is 0.2 m.

[6] In region 1 of Fig.1 $\mathbf{B}_1 = 1.2\ \mathbf{a}_x + 0.8\ \mathbf{a}_y + 0.4\ \mathbf{a}_z$ T. Find $\mathbf{H}_2$.

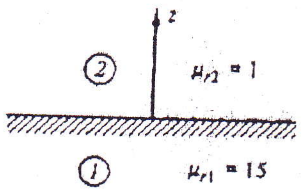


Fig.1

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